

EXHIBIT I

Photography 101

Fredo Durand
MIT CSAIL



APPLE V COREPHOTONICS
IPR2020-00905
Exhibit 2002

What do I know about good pictures?

- Not much: amateur photographer, wildlife, travel, portrait



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I like equipment

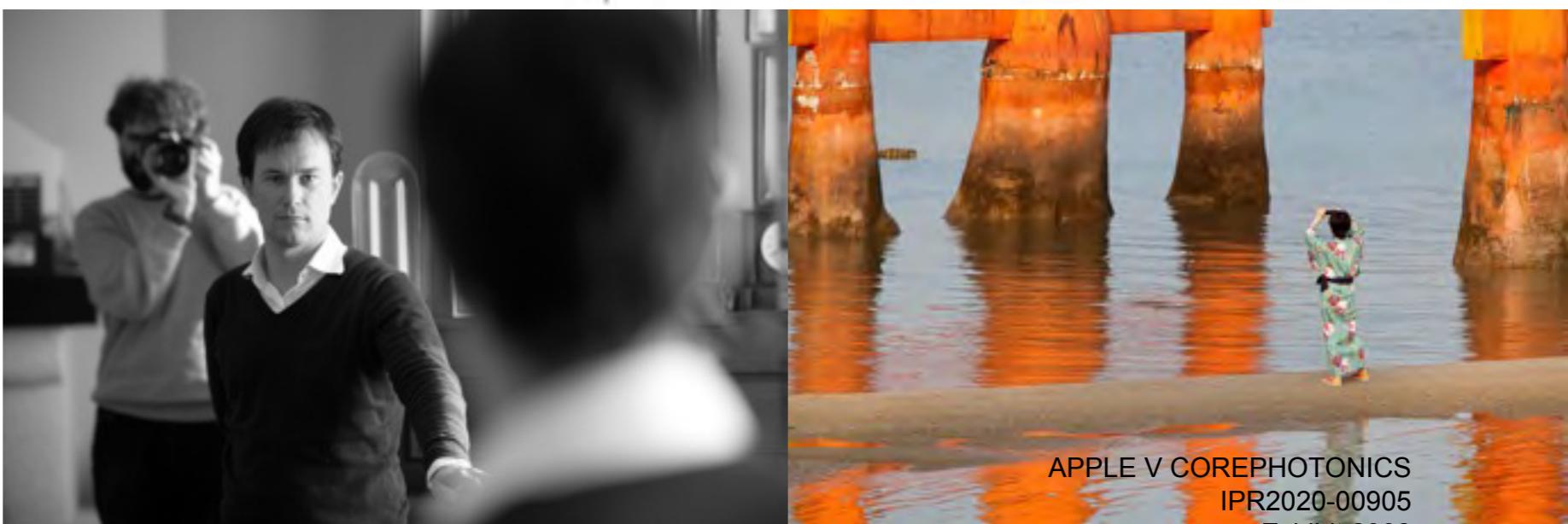
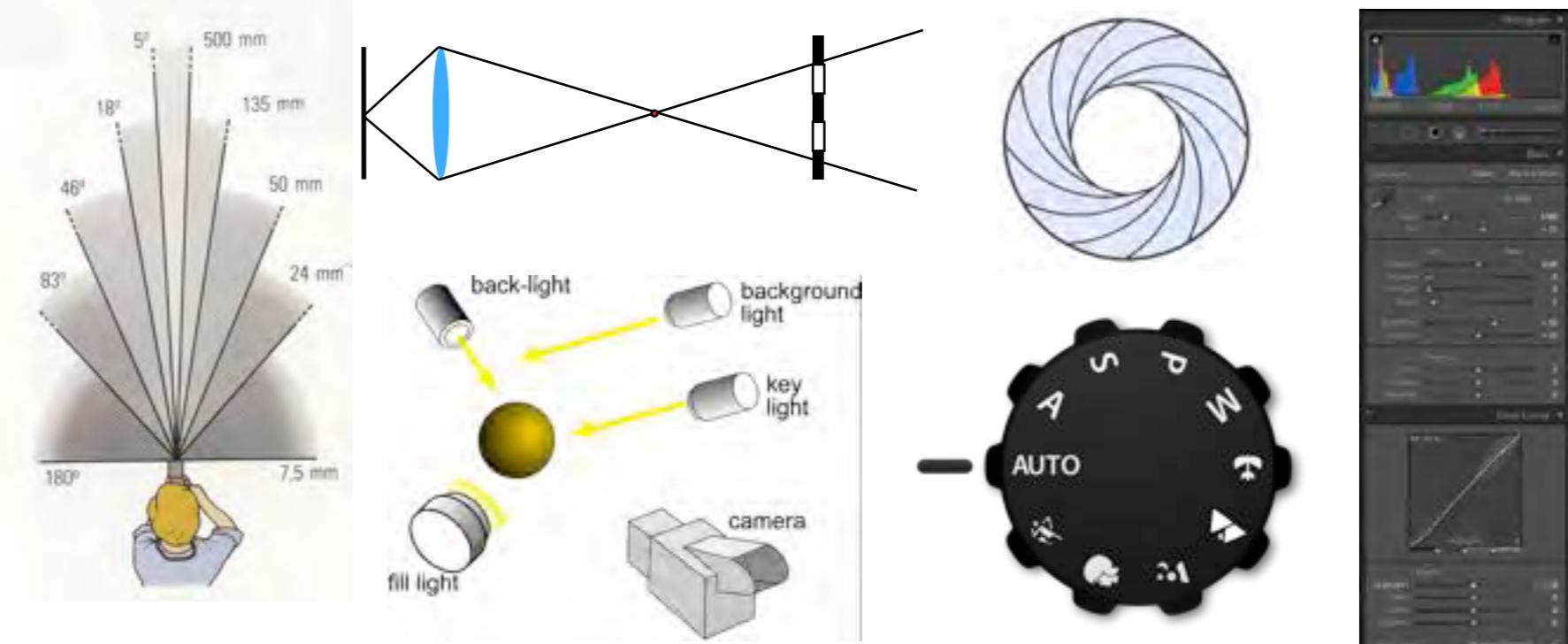
- I am a geek!



- Also I teach
 - 6.815 Digital and Computational Photography**
 - 6.865 Advanced Computational Photography**

Plan

- Imaging parameters
 - Camera
 - Lighting
 - Software



- Equipment
- Improving your pictures



Slides are online

- <http://people.csail.mit.edu/fredo/>
- More material at
 - <http://stellar.mit.edu/S/course/6/sp11/6.815/>
 - <http://graphics.stanford.edu/courses/#cs178>

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Short bio

Frédo Durand is an associate professor in Electrical Engineering and Computer Science at the Massachusetts Institute of Technology, and a member of the Computer Science and Artificial Intelligence Laboratory (CSAIL). He received his PhD from Grenoble University, France, in 1998, supervised by [Claude Tricot](#) and [Georges Dumont](#). From 1999 till 2002 he was a post-doc in the MIT Computer Graphics Group with [Julie Dorsey](#).

He works on [rendering](#), [image generation](#) and [computational photography](#), where new algorithms extract potential image enhancement and the design of imaging system that can reveal hidden information about a scene. His research interests span most aspects of picture generation and creation, with emphasis on mathematical analysis, signal processing, and inspiration from perceptual sciences. He organized the first [Symposium on Computational Photography and Vision](#) in 2005, the first [International Conference on Computational Photography](#) in 2008, and was on the advisory board of the [Image and Mining](#) conference. He received an inaugural [Computational Vision Researcher Award](#) in 2004 on [NSF CAREER](#) award in 2005, an inaugural [Michael J. Krizanich New Faculty Fellowship](#) in 2007, a [Stanford Younger Faculty Award](#) in 2008, and a [Spurz award for distinguished teaching](#) in 2007.

Students and collaborators

If you want to work with me, [EAD](#) for prospective students and post-docs.

[Vladimir Rockovskiy](#), [Jesse "Kris" Chen](#), [Eduardo Cole](#), [Abe Davis](#), [Tiffani Durdan](#), [Ranjanith Edith](#), [Jonathan Elizalde](#), [Kathy Folger](#), [Xiaoyi Guo](#), [Ariana Gutierrez](#), [Maia Kach](#), [Maia Kach](#), [Yann Kersch](#), [Yan Kersch](#), [Brett Kiefer](#), [Neginke Gohli](#), [Monica Drucker](#), [Jon Kline](#), [Jeffrey Krasny](#), [Tim Krupen](#), [Alyson Levy](#), [Will Hinschberger](#), [Mike Duggan](#), [Adriel Rosman](#), [Teng Song](#), [Xiaohui Ren](#), [Kevyn Orie](#), [Amit Ben-Artzi](#), [Kurtis Jaffer](#), [Paul Grana](#), [Ara Si](#), [Sumanth Rao](#), [Miles de Solla](#), [Amit Hasson](#)

Resources for students (potential resources about writing, career, being a successful graduate student). In particular see my lists of [tips on writing](#), [tips on giving a talk](#), [slides about my life](#), [tips about life](#), and [slides about life](#). For my students: [Policy](#), [Advisors](#), [rules](#), [etc](#).

Photos:

Scenic favorite

Everlasting

Tancrea

Ever-lasting

Lakeview

Bridge

Boily

Alaska

Born in Asia

Mandela & Dalai Lama

China

China

Rockport

New Orleans

Japan

Arizona

Colleagues

Colleagues

Colleagues

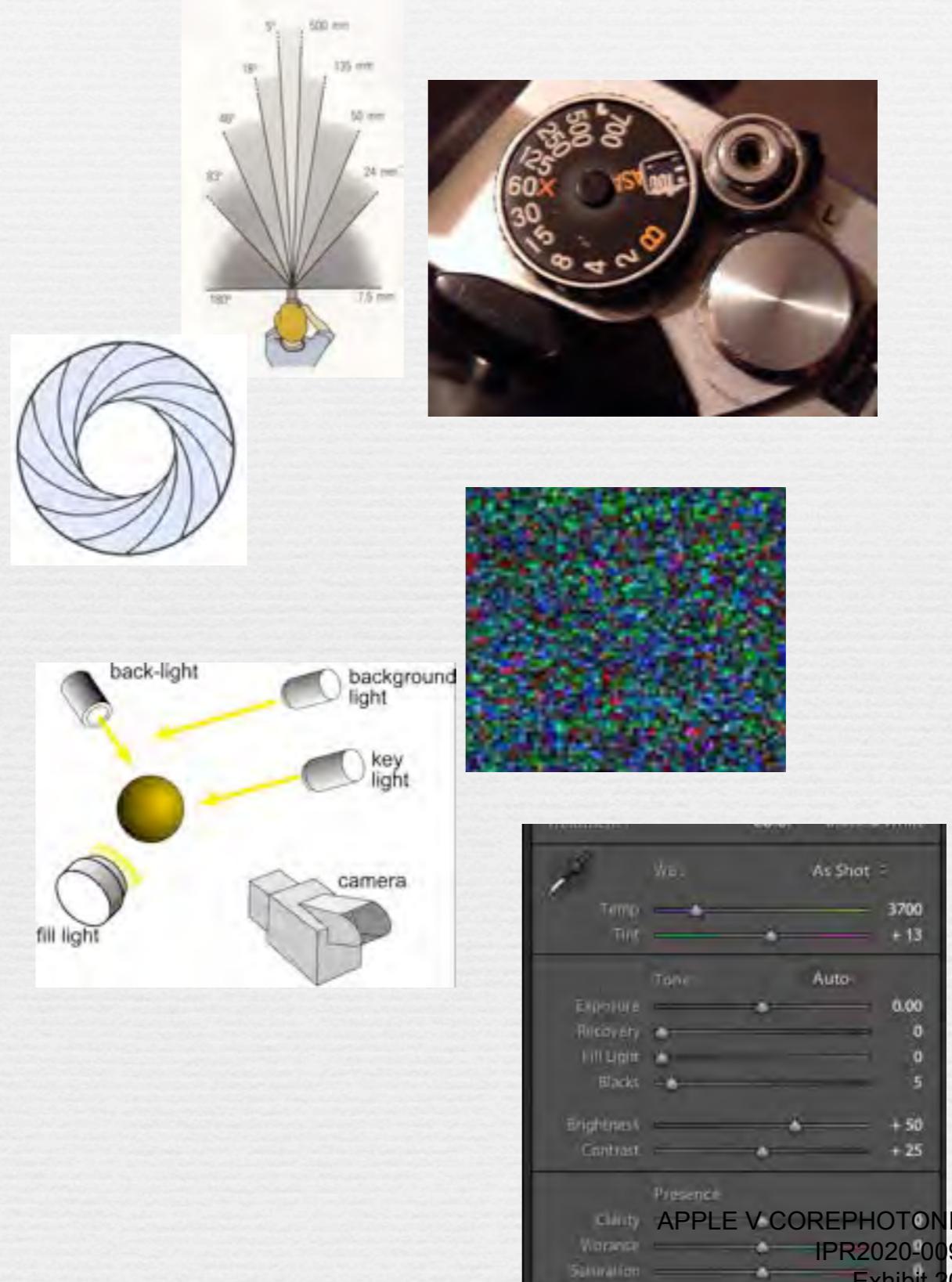
Colleagues

Imaging parameters

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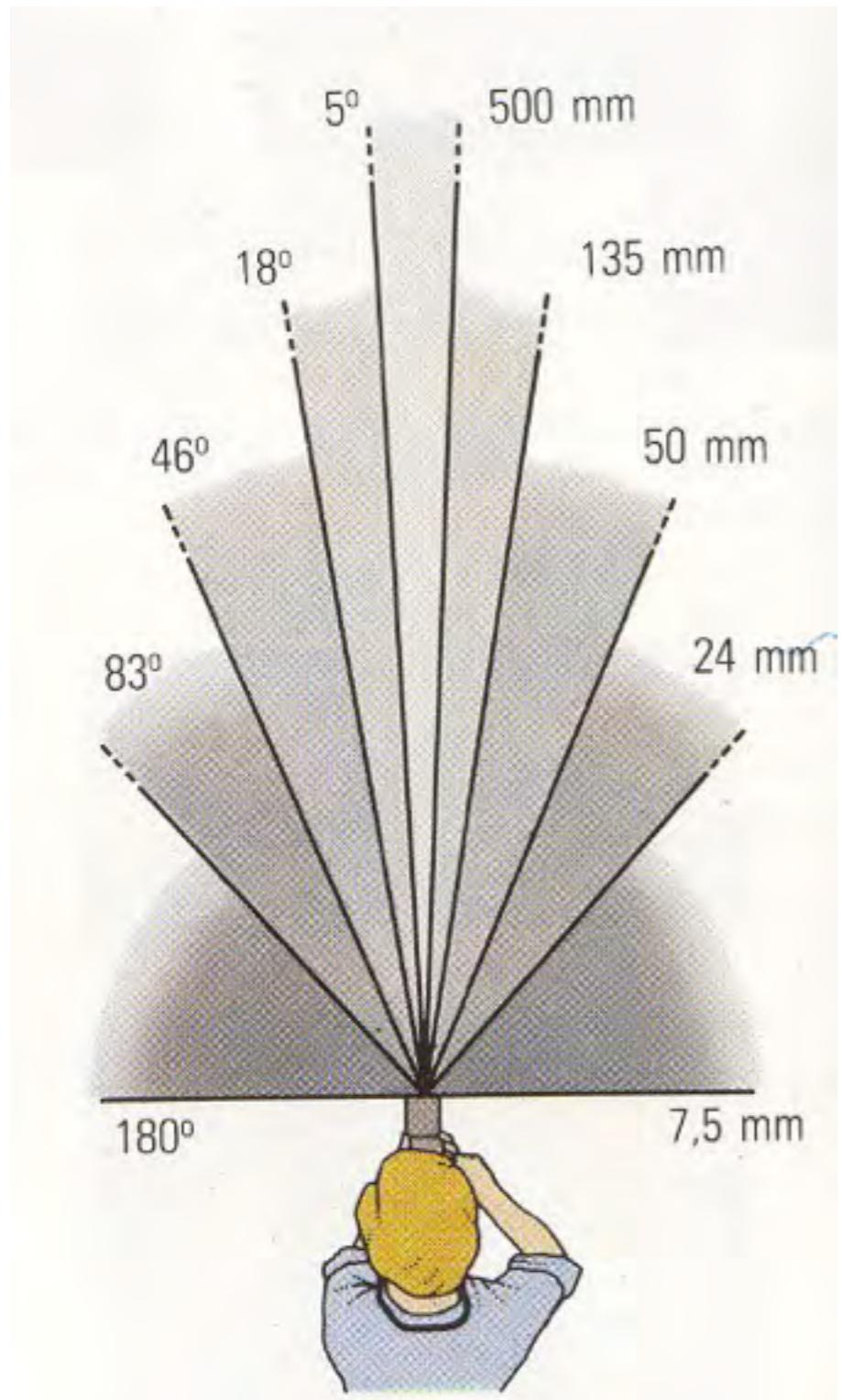
Imaging parameters

- ♦ Focal length
 - Sensor format
- ♦ Shutter speed
- ♦ Aperture
- ♦ ISO
 - Noise, sensor size
- ♦ Lighting
- ♦ Software

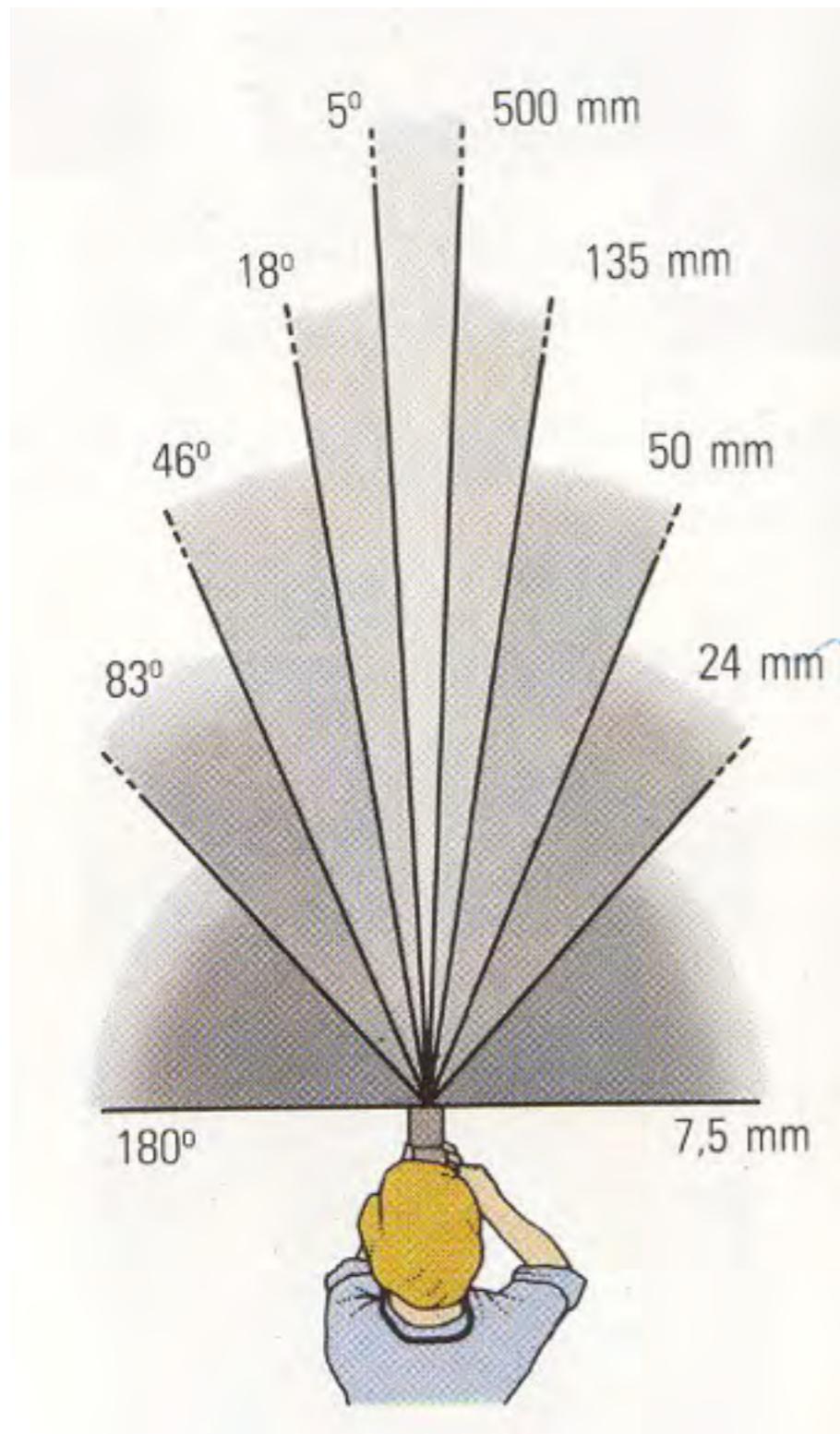


Focal length = field of view

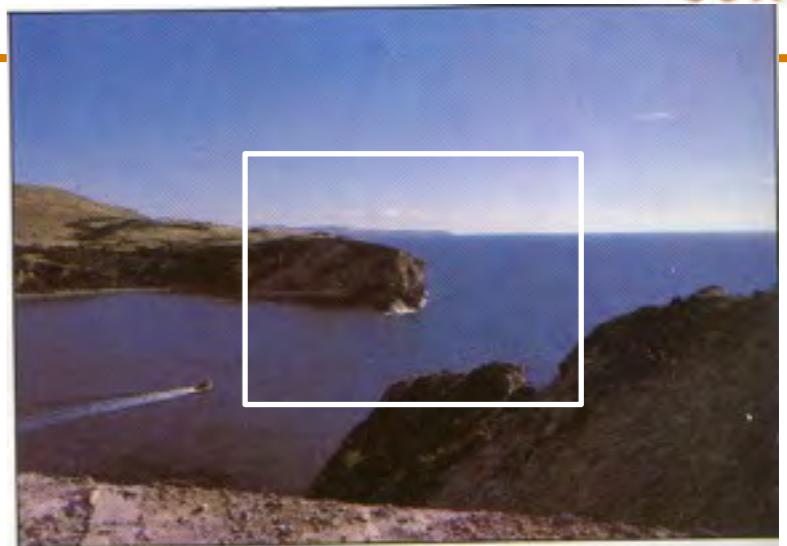
- zooming changes the focal length



Focal length = cropping



24mm



50mm

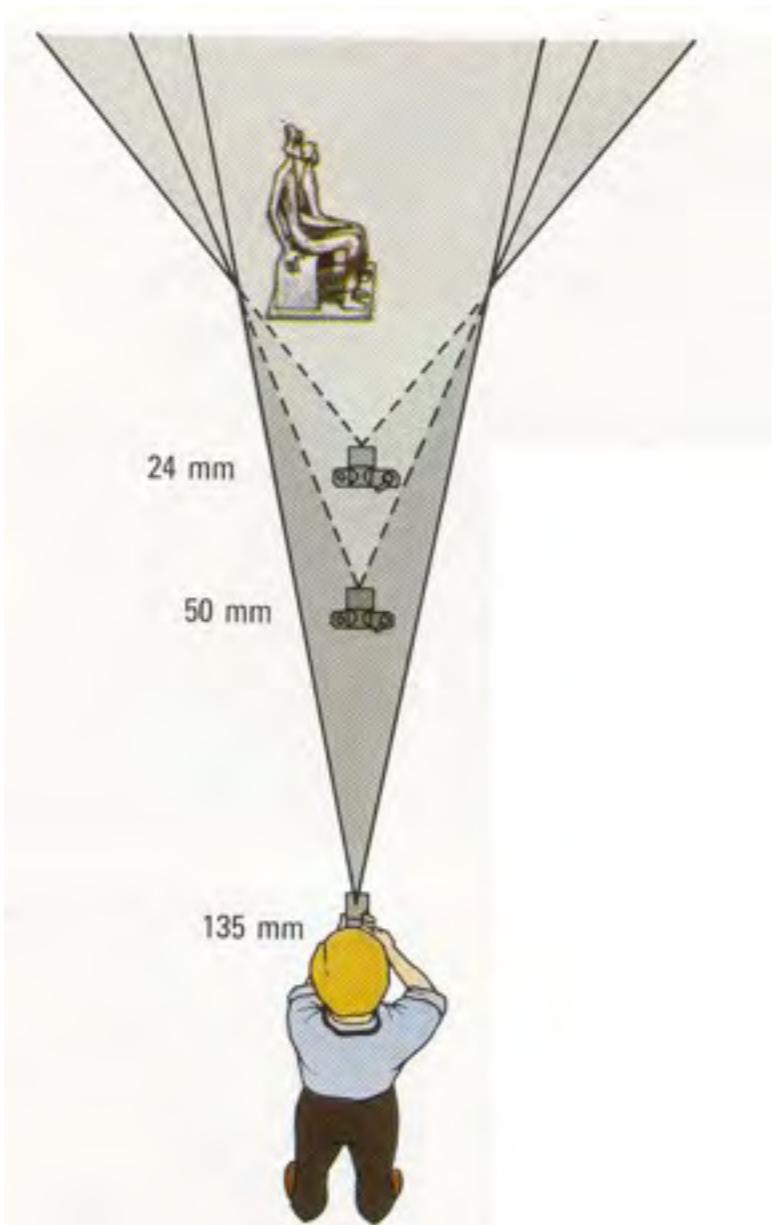


135mm



Focal length vs. viewpoint

- Telephoto makes it easier to select background (a small change in viewpoint is a big change in background).



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Perspective vs. viewpoint

- Portrait: distortion with wide angle
- Why?



Wide angle



Standard



Telephoto

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Very wide angle: include but distort

- Difficult lens to use because it includes so much
- enables wide range of scales



24mm

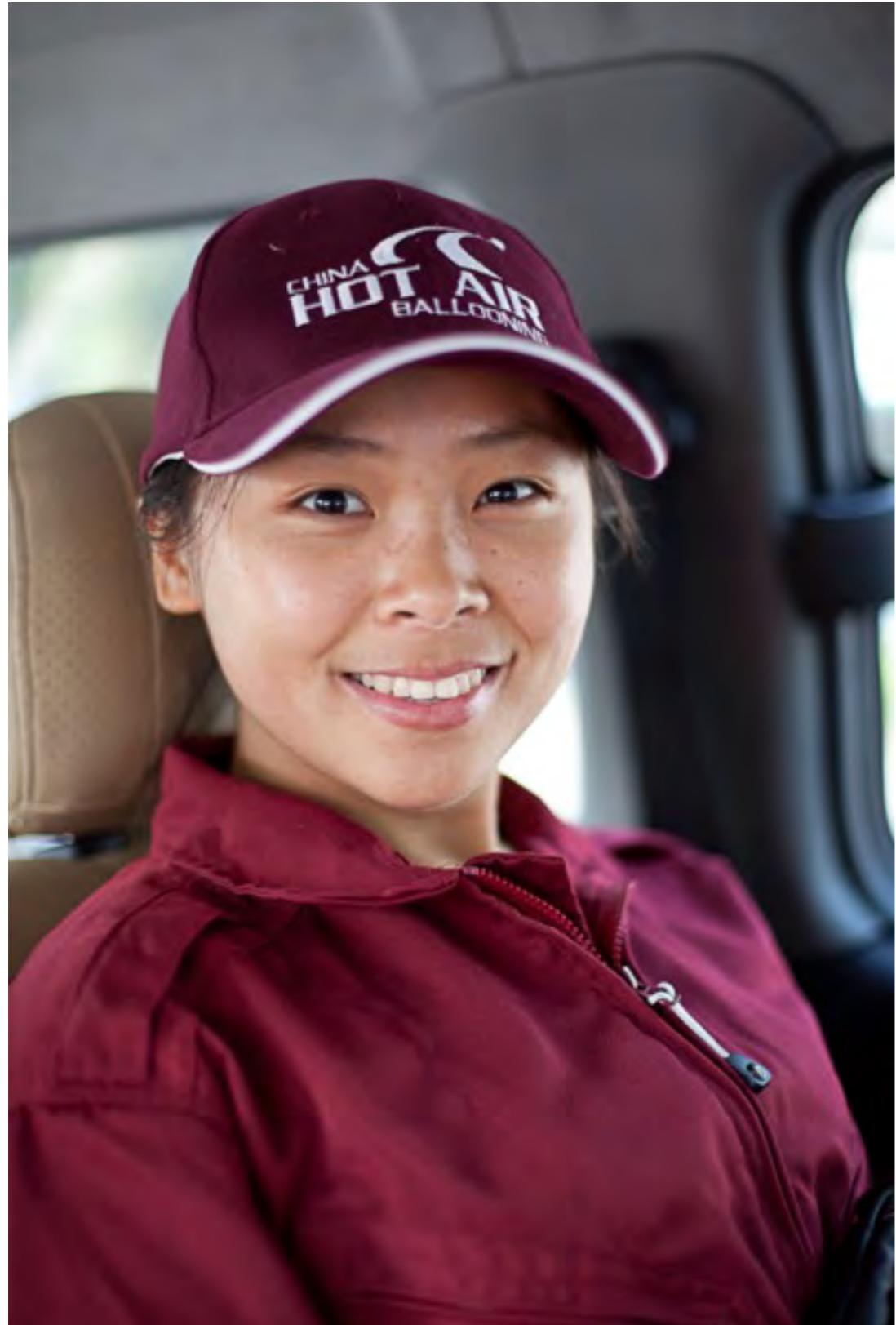


18mm



16mm
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Normal: neutral



50mm



55mm



50mm

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Medium telephoto: isolate



95mm



110mm



110mm



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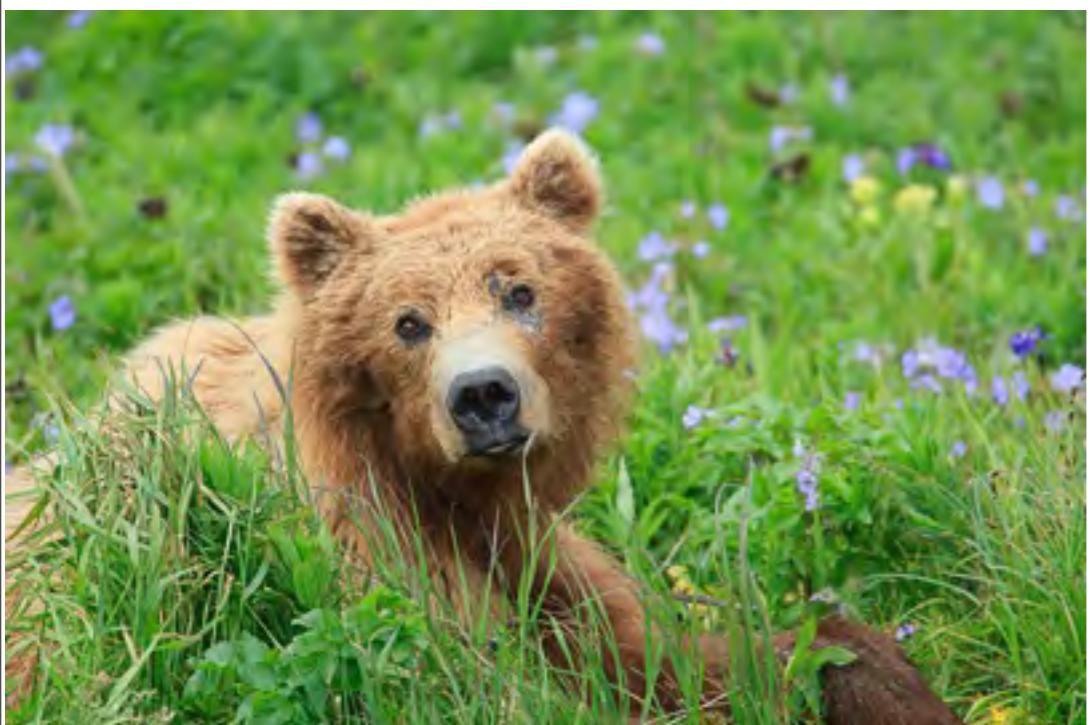
Super telephoto



910mm



910mm

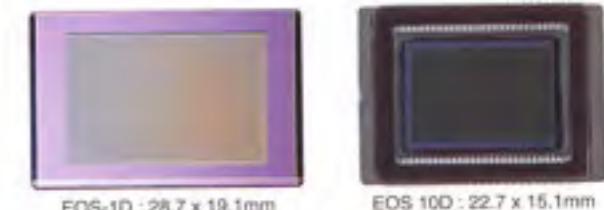


910mm

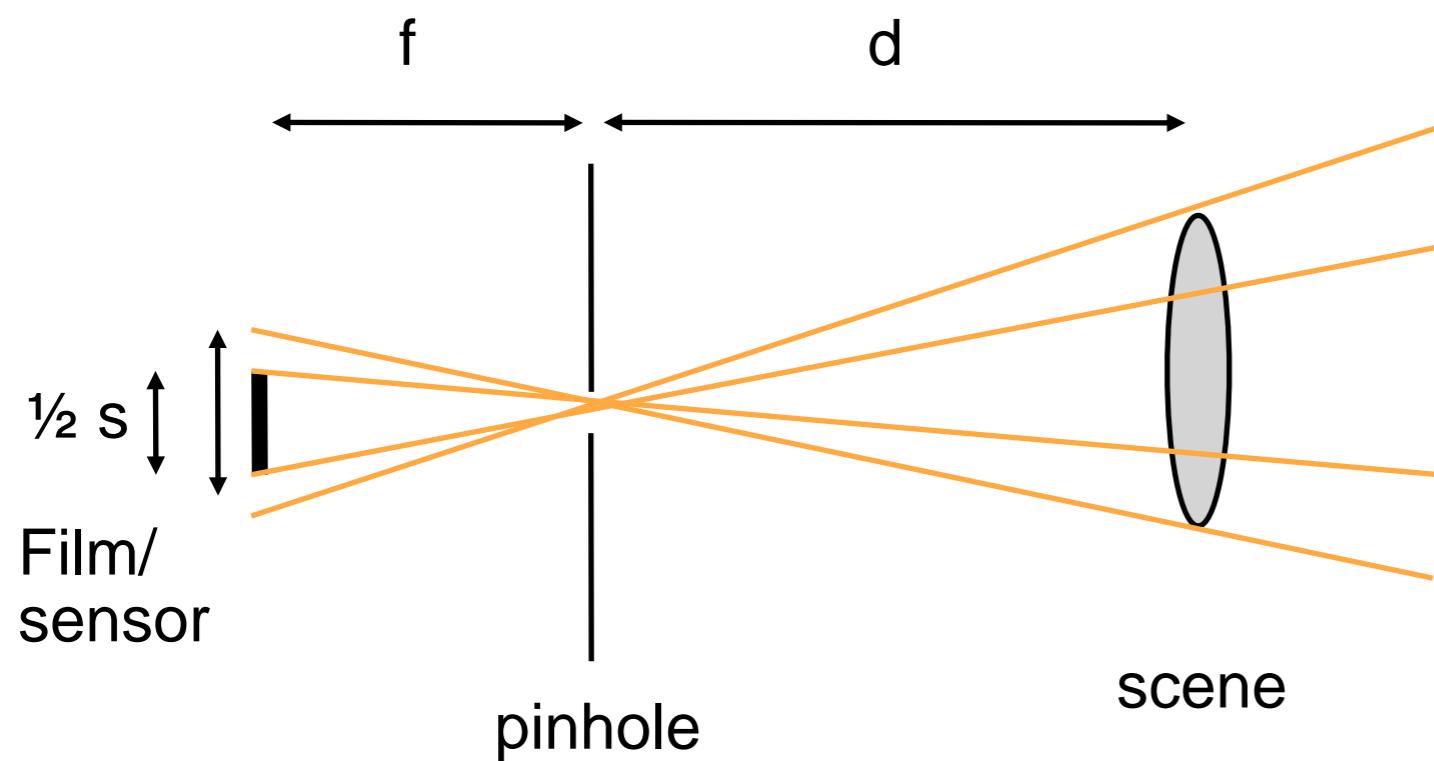


390mm

Focal length & sensor



- **What happens when the sensor is half the size?**
 - It's like cropping!
 - The field of view is reduced by a factor of 2
 - The equivalent focal length for is multiplied by 2
 - Hence the so-called crop factor, and the notion of 35mm equivalent focal length
- **Most affordable SLRs have a 1.5 crop factor**



http://www.photozone.de/3Technology/digital_1.htm



36x24mm (35mm format)

28.7x19.1mm (EOS 1D) = 1.26x magnification factor

APS-C sized sensors (EOS 10D, Nikon D100, Pentax *ist D, etc) = 1.5x - 1.6x

18x13.5mm (4/3" system - Olympus E-1)

8.8x6.6mm (2/3" P&S)

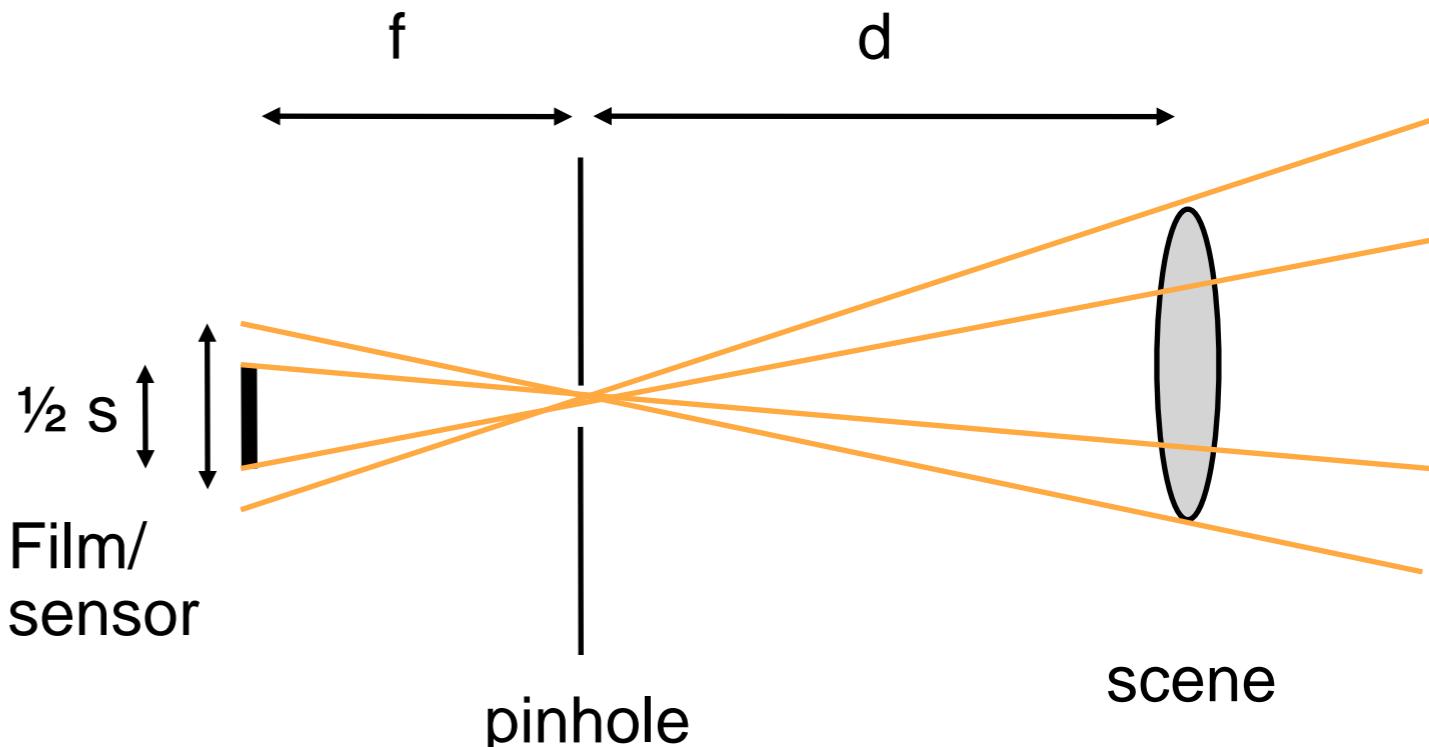
8.8x6.6mm (2/3")

7.2x5.3mm (1/1.8")

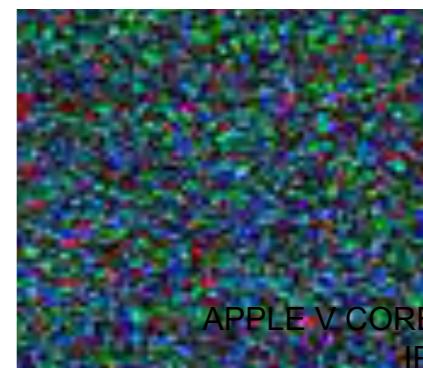
5.3x4mm (1/2.7")

Consequences of smaller sensor

- Different field of view for same focal length
 - hence the “crop factor”
 - a 100mm on a low-end SLR has the same field of view as a 150mm on a high-end one



- Larger depth of field
- Increased noise



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Recap: focal length

- **focal length**
= field of view
= cropping
- depends on sensor size
- zooming changes the focal length
 - wide angle : <35mm
 - telephoto : > 85mm
- difference between viewpoint and focal length

